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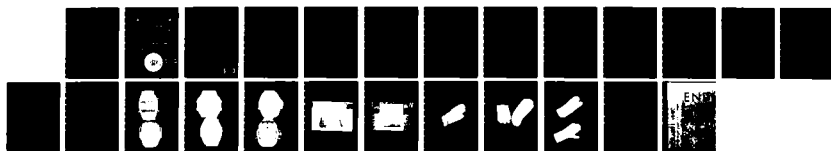
EVALUATION OF DIGITAL DIVING WATCHES(U) NAVY
EXPERIMENTAL DIVING UNIT PANAMA CITY FL E S MORRISON
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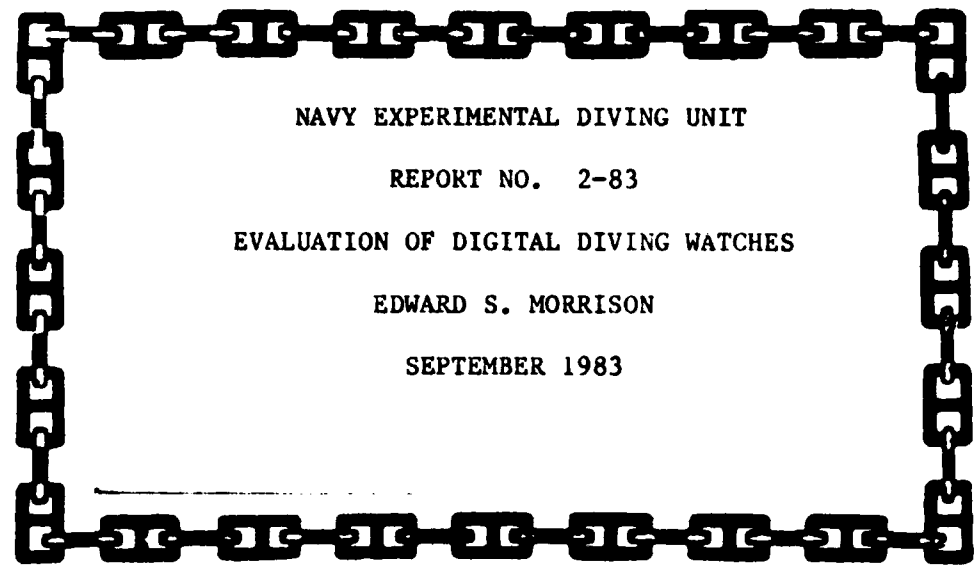




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NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 2-83

EVALUATION OF DIGITAL DIVING WATCHES

EDWARD S. MORRISON

SEPTEMBER 1983

NAVY EXPERIMENTAL DIVING UNIT



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DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407

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Testing encompassed suitability, durability, pressure, thermal stress, luminescence and magnetic signature tests. Throughout testing the watches performed adequately with the exception of the magnetic signature tests. Based on information gathered during testing the watches are considered to be reliable time keepers, robust and suitable for use by U.S. Navy divers.

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Glossary

analog watch	watch with a dial type face
bezel	a rotatable ring of figures mounted on a watch face
digital watch	utilizing digits one to ten
EOD	Explosive Ordnance Disposal
FPM	feet (foot) per minute
FSW	feet-of-seawater
OSF	Ocean Simulation Facility
para	paragraph

Abstract

In March/April 1982, NEDU evaluated a selection of diving watches utilizing a digital display window. The purpose was to find suitable digital watches for use during U. S. Navy diving activities. The watches tested had similar methods of activation and an integral light, except the two analog types which had no integral illumination but were fitted with elapsed time bezels.

Testing encompassed suitability, durability, pressure, thermal stress, luminescence and magnetic signature tests. Throughout testing the watches performed adequately with the exception of the magnetic signature tests. Based on information gathered during testing the watches are considered to be reliable time keepers, robust and suitable for use by U.S. Navy divers.

KEY WORDS: Watches
Digital
Elapsed Time

I. INTRODUCTION

In March/April 1982 NEDU conducted an evaluation of six digital diver watches; four totally digital and two analog type with a secondary digital display. Two of the six digital watches were manufactured by SEIKO, two by CASIO and the remaining two analog type manufactured by CHRONOGRAPH, and HUER. Testing was conducted to find suitable digital watches that could be used by the U.S. Navy diver. Tests carried out at NEDU did not include an evaluation of all the watches operation modes or testing in night diving conditions and was designed only to evaluate their reliability, accuracy, robustness and ability to stand up to normal diver use. The stop watch function of each watch was used in tests carried out in open water, and during glove tests. In addition to these tests, the watches were evaluated with respect to their magnetic signature for possible use by Navy EOD teams.

The watches chosen for test provided a cross section of available digital type watches representative of the available U.S. market.

II. EQUIPMENT DESCRIPTION

The digital diving watches display a variety of features in addition to allowing a diver to keep track of his bottom time. Table 1 contains a list of the various functions available in each model and Figures 1 through 6 in APPENDIX A are pictures of the various models tested.

III. TEST PROCEDURE

A. Suitability Tests. Human engineering studies and durability tests carried out at NEDU and at sea during open water dives consisted of the following:

1. Nut Retrieval Tests. This test was designed to simulate the worst punishment a diving watch could be subjected to by a working diver. It consisted of having a Diver-Subject retrieve 50 hexagonal headed nuts from a baffled box. The configuration of this box required that the Diver-Subject reach through a circular hole on one side of the box, through a baffle with a notched slit provided for access, to the bottom of the opposite side of the box, locate and retrieve a nut, finally placing it in a bucket outside the box. This retrieval action was repeated as fast as possible utilizing the non-dominant hand with the watch to be tested on the wrist area of the arm. At the beginning of testing, each watch tested was started to record bottom time as the diver entered the water to perform the retrieval test. Upon completion of the retrieval of the 50 nuts, the Diver-Subject returned to the surface to ensure that the bottom time had not been inadvertently secured or altered when compared to a stop watch running simultaneously topside. APPENDIX B (Figures 7 and 8) contains pictures of the nut retrieval box used for the evaluation.

2. Glove Tests. For additional in-water testing, the Diver-Subject donned various types of wet suit jackets and gloves, including dry-suit thermal protection gloves. Wearing each glove in turn the diver started, stopped and reset the stop watch function of each watch. To ensure the gloves

TABLE 1

WATCH MODEL NUMBERS, AVAILABLE FUNCTIONS, AND MANUFACTURER ADDRESSES

TYPE WATCH	MODEL NO. / NAME	ALARM FUNCTION	COUNT DOWN TIMER, ALARM	STOPWATCH	TIME, DAY, DATE FUNCTION	FACE ILLUMINATION	DEPTH RATING	MANUFACTURERS MAIN ADDRESS
CASIO (DIGITAL)	106H/ 110	YES	YES	YES	YES	YES	328 FT	CASIO COMPUTER CO LTD SHINJUKO-SUMITOMO BLDG 2-6 TOKYO, JAPAN
CASIO (DIGITAL)	106H/ 101	YES	YES	YES	YES	YES	328 FT	NISHI-SHINJUKO SHINJUKO-KO. TOKYO, JAPAN
SEIKO (DIGITAL)	A547/ 5059	YES	YES	YES	YES	YES	328 FT	K. HATTORI 8 CO LTD 621 KYOBASH, CHROME, CHOO-KO.104 TOKYO, JAPAN
SEIKO (DIGITAL)	A639/ 5029	YES	YES	YES	YES	YES	328 FT	K. HATTORI 8 CO LTD 621 KYOBASH, CHROME, CHOO-KO.104 TOKYO, JAPAN
CHRONOSPORT UDT (ANALOG/ DIGITAL)	SEAQUARTZ	NO	NO	YES DIGITAL	YES	NO	330 FT	CHRONOSPORT SERVICE CENTER, 119 ROWATON AVE., ROWAYTOM, CT 06853
HEUER (ANALOG/ CHRONOGRAPH DIGITAL)	NOT DESIGNATED CHRONO- GRAPH	NO	NO	YES DIGITAL	YES	NO	330 FT	HEUER-LEONIDAS SA CH-1501 BIE-BIWNE SWITZERLAND

retained maximum thickness, watch activation was carried out on the surface of NEDU's Test Pool. Comments for each watch versus glove combination were recorded by the Human Engineer representative. APPENDIX C (Figures 9 thru 12) contains pictures of the gloves used for the evaluation.

3. **Durability Tests.** The watch was tested for the reliability of its case and actuation buttons to stand up to normal use by a diver. This test was an integral part of the nut retrieval, glove and open water tests.

4. **Luminescence Tests.** All watches were uniformly mounted and placed in a darkened room. A series of subjects viewed the watches to determine the greatest viewing distance that the digital display or watch face could be read with complete accuracy both with and without the watches' integral light actuated. Two of the test subjects had corrected vision.

B. Manned Open Water Tests. Open water dives were conducted to evaluate the following:

1. Diver comfort.
2. Ease with which the digital readout could be read underwater.
3. Operation of the stop watch function using bare hands.

After each open water dive the Diver-Subjects filled out a questionnaire, evaluating comfort, legibility of display, and ease of actuating the stop watch start button. Visibility underwater at the time of testing was in excess of 15 ft. and button activation was carried out using bare hands.

APPENDIX D contains a sample of the questionnaire filled out by each of four different Diver-Subjects following the open water dives.

C. Unmanned Tests

1. **Pressure Tests**

a. To assess its watertight integrity, each watch was placed in a fresh water bath and pressurized in a hyperbaric chamber. Pressurization was staged to a maximum depth of 330 FSW. Between each pressurization the watch was surfaced at 60 FPM to check its watertight integrity. The following schedules were used:

- (1) 100 FSW for 10 minutes.
- (2) 175 FSW for 10 minutes.
- (3) 200 FSW for 10 minutes.
- (4) 330 FSW for 10 minutes.

Compress rate did not exceed 75 FPM.

2. Thermal Stress Tests. The effect of temperature on watch accuracy and watertightness were evaluated by conducting a time check on each watch against a Hewlett Packard HP 1000 series digital clock and then immersing them in a fresh water bath at the following temperatures:

- a. $30^{\circ}\text{F} \pm 5^{\circ}\text{F}$.
- b. $50^{\circ}\text{F} \pm 5^{\circ}\text{F}$.
- c. $70^{\circ}\text{F} \pm 5^{\circ}\text{F}$.
- d. $90^{\circ}\text{F} \pm 5^{\circ}\text{F}$.

The watches were then pressurized to a depth of 100 FSW at the above temperatures and left for four days. At the end of each 24 hours watch accuracy was checked against the HP digital clock which has an accuracy of ± 1 minute a month.

3. Magnetic Signature Tests. Upon completion of manned and unmanned testing, the watches were tested for magnetic effect at the Naval Explosive Ordnance Disposal Technology Center, Indian Head, MD. They were tested in accordance with the military specifications for a watch suitable for use in EOD operations.

IV. RESULTS

A. Suitability Tests

1. Nut Retrieval Tests. The actions carried out during the test resulted in alteration or stoppage of the pre-set stopwatch function in all of the watches. None of the watches suffered damage to its watertight case or actuation buttons. All watches continued to display a normal time function when so programmed.

2. Glove Tests. For both glove and mitt, it was difficult and time consuming to find the stop watch activation button on all the watches. Once found, several attempts were required to activate the stop watch function. The same problem occurred when stopping and resetting the stop watch. APPENDIX A has pictures of the gloves used for the evaluation.

B. Manned Open Water Human Engineering and Durability Tests. There were no watch body, strap breakage or time malfunction recorded during open water tests. During this phase of testing, the digital watches proved to be extremely durable, easily absorbing the knocks, and hazards associated with diving from a small craft. Results of the questionnaire filled out by each Diver-Subject are summarized in Table 2.

C. Unmanned Tests

1. Pressure Tests. None of the watches showed signs of water leakage and continued to function without fault.

TABLE 2
RESULTS OF DIGITAL WATCH QUESTIONNAIRE

WATCH MODEL	CASIO 106 H 110	CASIO 106 H 101	SEIKO A639-5029	SEIKO A547-5059	CHRONOSPORT SEAQUARTZ	HEUER CHRONOGRAPH
DIGITAL DISPLAY LEGIBILITY	3	3	2.75	2.5	3	3
ACTIVATION CHARACTER- ISTICS	3	2.75	3	2.75	2.75	3
RATINGS BASED ON GENERAL COMMENTS	2	2	2	2	2	2

NOTE: THE FIGURES GIVEN ARE THE AVERAGE FROM FOUR DIVER-SUBJECTS USING A RATING SCALE OF: 1 FOR EXCELLENT TO 5 FOR POOR.

2. Thermal Stress Tests. None of the watches showed any time keeping error greater than ± 1 second in any 24 hour period. None of the watches leaked during this test.

3. Luminescence Tests. The watch face figures were discernable to a maximum distance of 30 inches from the eyes of each viewing subject when measured in a direct line on the surface. The digital figures could not be read without using the integral watch light. Not having a means of illumination the digital displays on the two analog type watches could not be read. However, the luminous hand figures and bezel markings remained visible to the same viewing distance as the totally digital watches.

4. Magnetic Signature Tests. Non-magnetic signatures of all watches was greater than the maximum non-magnetic reading permitted for work on magnetic influence ordnance by reference (a).

D. Discussion

1. Nut Retrieval Test. This test simulated worst case working conditions and it is unlikely that a diver would subject his watch to this type of punishment. It is suggested that when working in confined areas the diver cover his watch using a neoprene band or wear a glove which extends on the wrist far enough to cover his watch. The interruption of the stop watch function was found to be avoided by changing modes of display after activating the stopwatch function. The stopwatch time was then recalled when required.

2. Glove Test. A diver must give consideration to the method and choice of watch used to record bottom time. A solution to the button activation problem was found in using the point of the divers knife to activate the button. The use of the watch which offers the rotatable bezel in conjunction with a digital display window provides a more convenient method of recording time yet was also subject to errors caused by movement of the bezel.

3. Thermal Stress Test. In the successful completion of this test, the watches met the current Military Specifications (reference a) for a watch (± 30 seconds a day).

4. Luminescence Test. A distance of 30 inches was established as maximum reasonable viewing distance using integral watch lighting or existing luminescence. The likelihood of a diver viewing his watch from this distance is remote. It was also assumed that he would move it to the most advantageous position for reading the face. The watches were not tested in open water in night diving conditions, but providing visibility is better than zero, it can be concluded from the testing in ideal conditions and total darkness that the watch faces, bezel and figures can be seen with minimum difficulty using the background integral light.

V. CONCLUSIONS

The digital diving watches tested at NEDU were effective in normal use by a diver.

Digital diving watches are suitable for the U.S. Navy diver as long as they have some form of "elapsed time" function incorporated to allow measurement of bottom time and consideration is given to the conditions and method of activation when thermal protection is required.

The digital diving watches tested were not suitable for EOD applications when low magnetic signatures are required.

VI. REFERENCES

A. Military Specification MIL-W-22176A Watch, Wrist, Submersible (400 foot) Non-magnetic.

APPENDIX A
PHOTOGRAPHS OF WATCHES TESTED



FIGURE 1
MODEL NO.
A639-5029

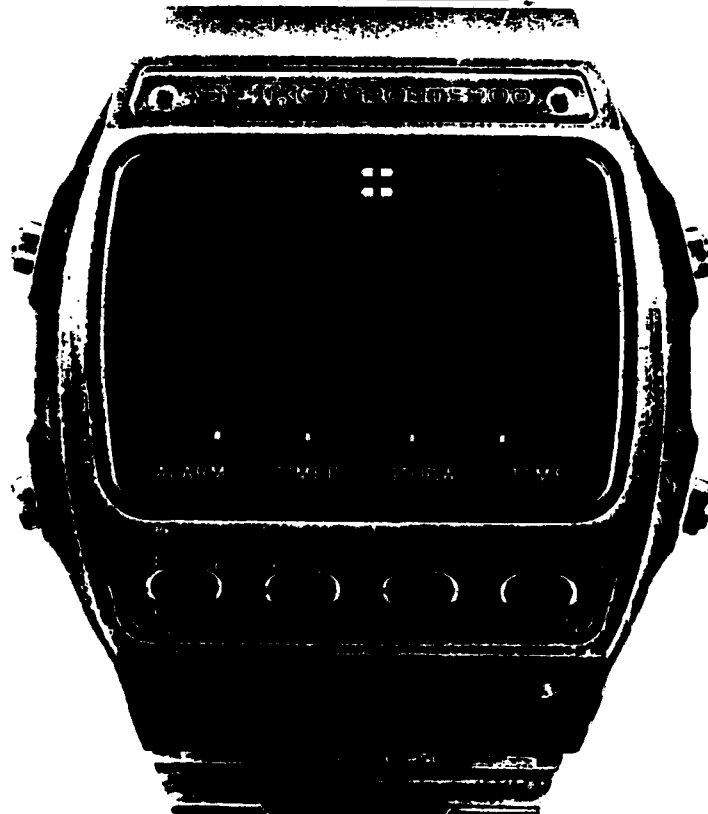


FIGURE 2
MODEL NO.
A547-5059

APPENDIX A
PHOTOGRAPHS OF WATCHES TESTED

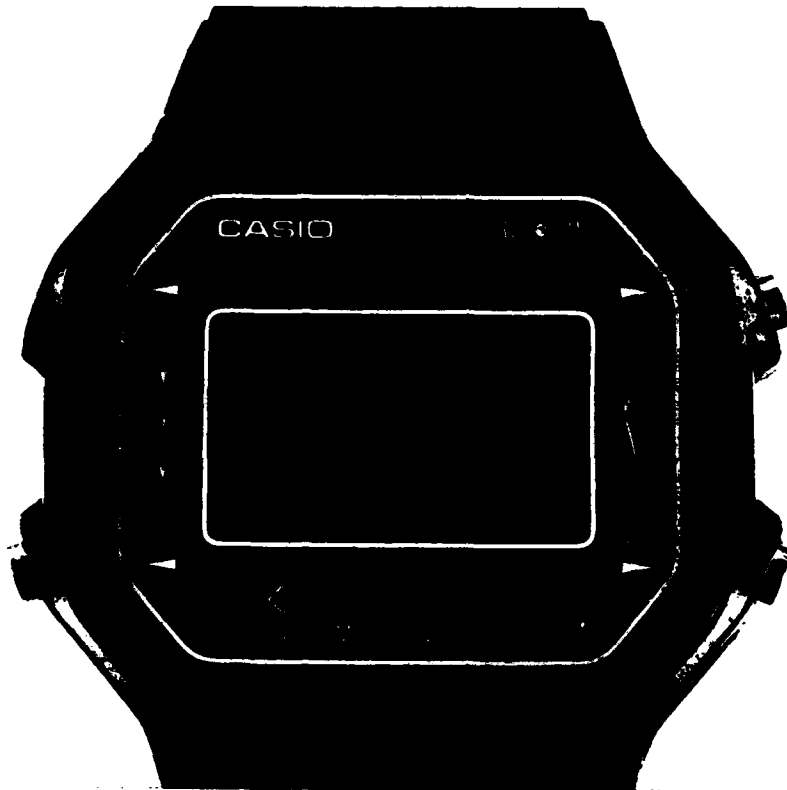


FIGURE 3
MODEL NO.
106 H 110

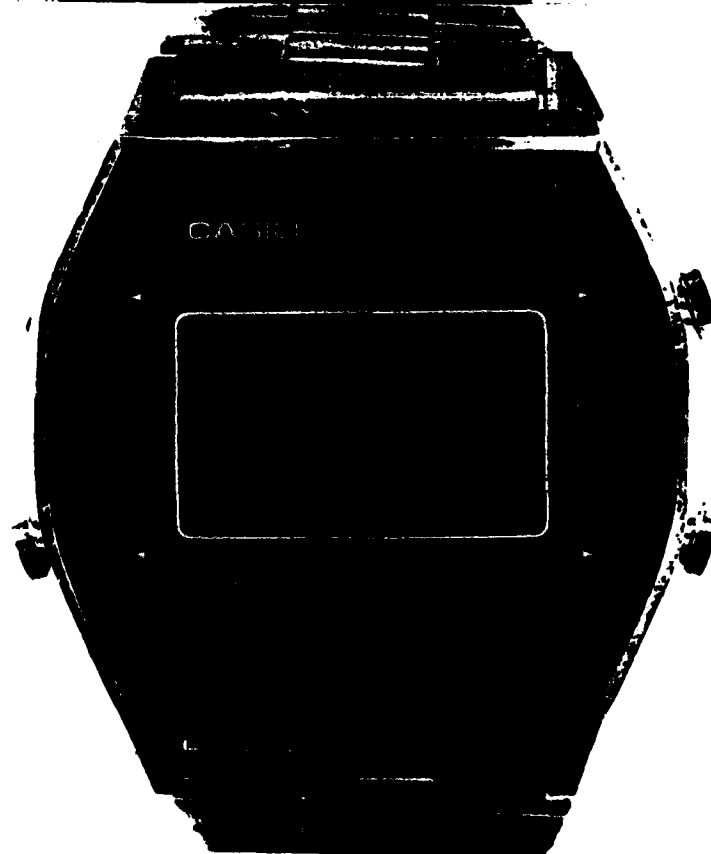


FIGURE 4
MODEL NO.
106 H 101

APPENDIX A
PHOTOGRAPHS OF WATCHES TESTED

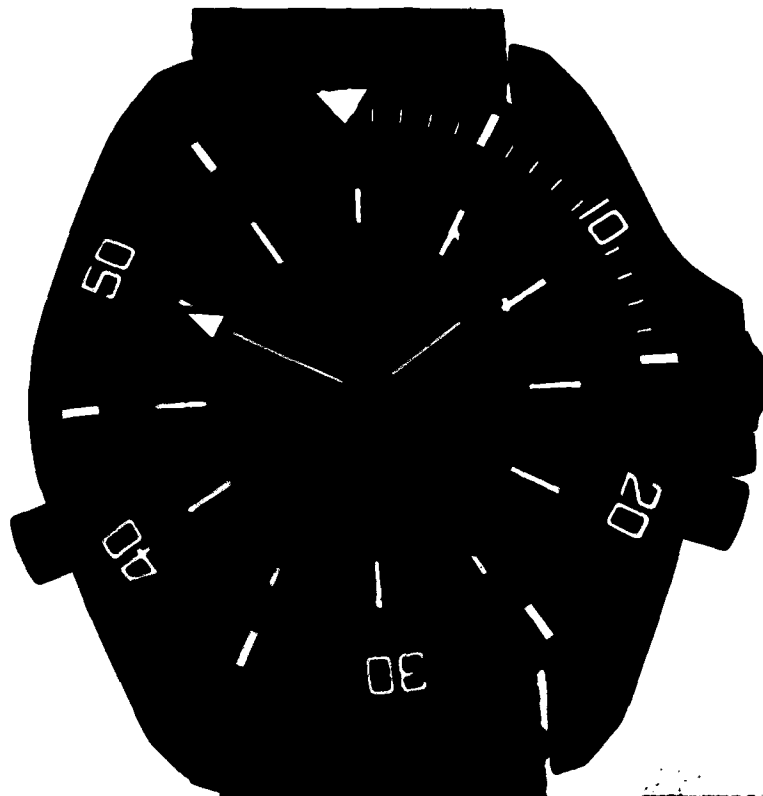


FIGURE 5
CHRONOSPORT
UDT
SEAQUARTZ



FIGURE 6
HEUER
CHRONOGRAPH

APPENDIX B

PHOTOGRAPH OF NUT RETRIEVAL BOX
USED DURING DURABILITY TESTS



FIGURE 7. SHOWING ENTRY HOLES IN RETRIEVAL BOX TOP

APPENDIX B

PHOTOGRAPH OF NUT RETRIEVAL BOX
USED DURING DURABILITY TESTS

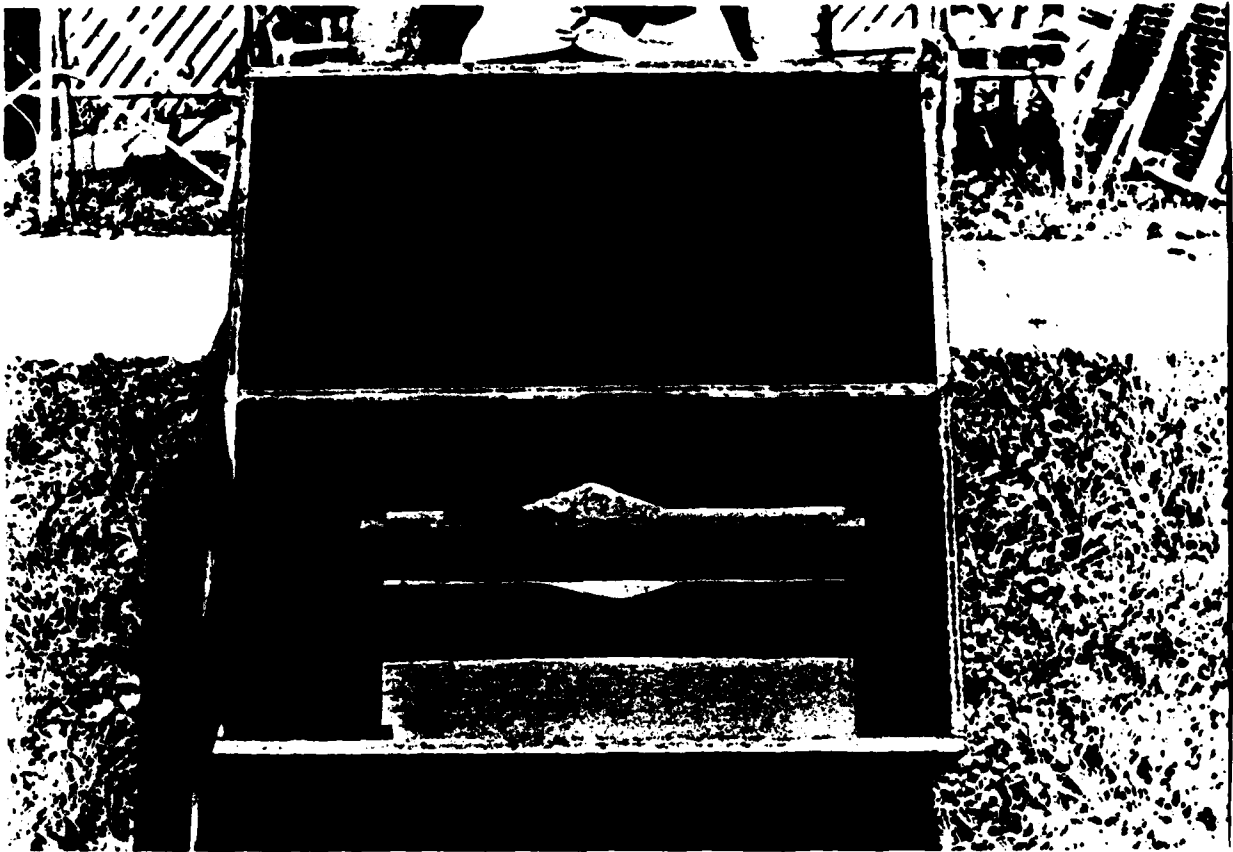


FIGURE 8. SHOWS INSIDE OF RETRIEVAL BOX

APPENDIX C
PHOTOGRAPHS OF GLOVES USED DURING TESTS

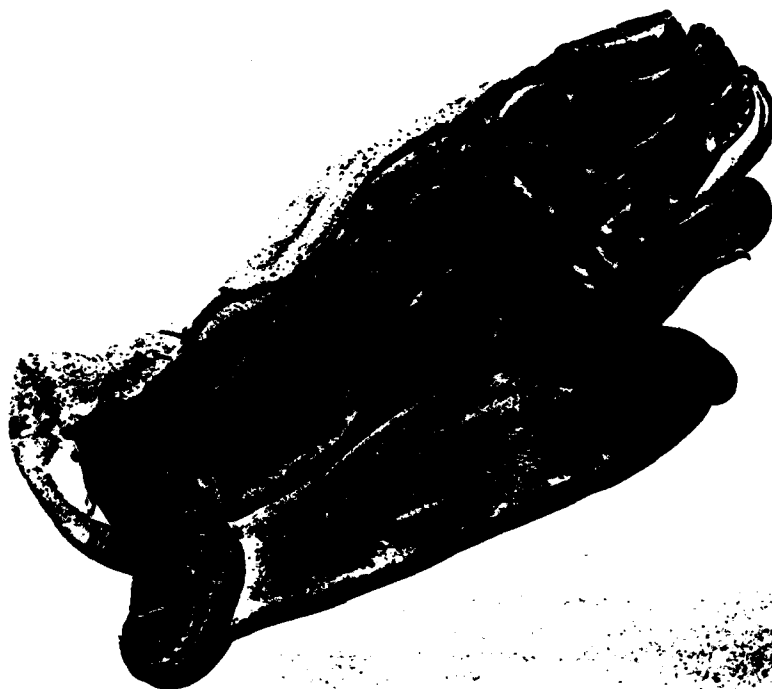


FIGURE 9. LEATHER GLOVE

APPENDIX C
PHOTOGRAPHS OF GLOVES USED DURING TESTS



FIGURE 10. PASSIVE DIVER THERMAL PROTECTION GLOVE (OUTER & INNER)

APPENDIX C
PHOTOGRAPHS OF GLOVES USED DURING TESTS



FIGURE 11
WET SUIT
MITTEN

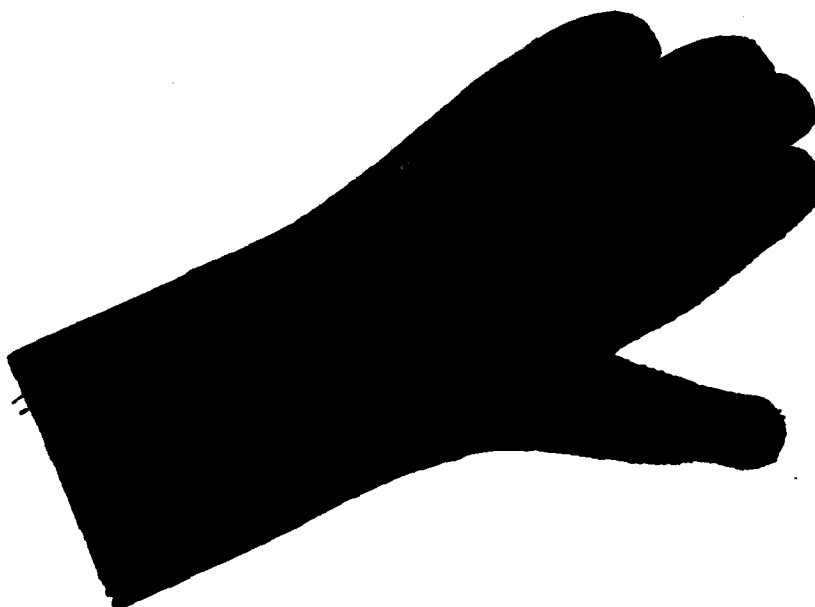


FIGURE 12
WET SUIT
GLOVE

APPENDIX D

DIGITAL WATCH QUESTIONNAIRE

NAME _____ DATE _____
DEPTH _____ FT TOTAL BOTTOM TIME _____ MIN VISIBILITY _____ FT
WATCH MODEL # _____

FROM THE RATING SCALE, CHOOSE THE NUMBER REPRESENTING THE ANSWER WHICH BEST FITS.

	EXCELLENT				POOR
RATING SCALE:	1	2	3	4	5

1. RATE THE LEGIBILITY OF THE DIGITAL WATCH DISPLAY: _____
2. RATE THE ACTUATION CHARACTERISTICS OF THE WATCH BUTTON/S: _____
3. COMMENTS: _____

